IMPROVED REMANENT SUPERMIRROR POLARIZERS

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Neutron spin polarizers based on Fe/Si and $Fe_{.89}Co_{.11}$/Si supermirrors were prepared by magnetron sputtering. For these polarizing efficiencies of 96 % to 98 % could be reached in transmission when operated in a guide field of $<$ 20 G.

$3T$ We are working on the optimization of magnetically remanent supermirror neutron polarizers. The aim is to build compact neutron transmission polarizers [1] and polarizers to be operated in an antiparallel magnetic field. A possible application is shown in Fig. 1.

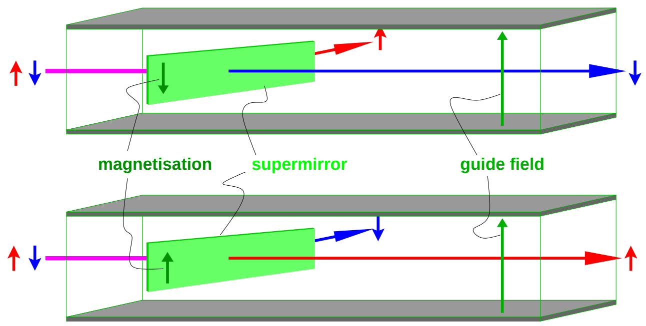

Fig.1: Spin filter based on a remanent supermirror polarizer. If the coercitive field strength of the polarizer is larger than the guide field, it is possible to have it polarized antiparallel (upper sketch) and parallel (lower sketch) to the guide field. This allows to select a spin state without using a spin flipper just by magnetizing the polarizer in a certain direction.

The supermirrors are prepared by magnetron sputtering using the low absorbing materials Fe or $Fe_{.89}Co_{.11}$ and Si. The sputter parameters like power, gas pressures and addition of the reactive gases O_2 and N_2 were optimized by producing multilayers on glass.

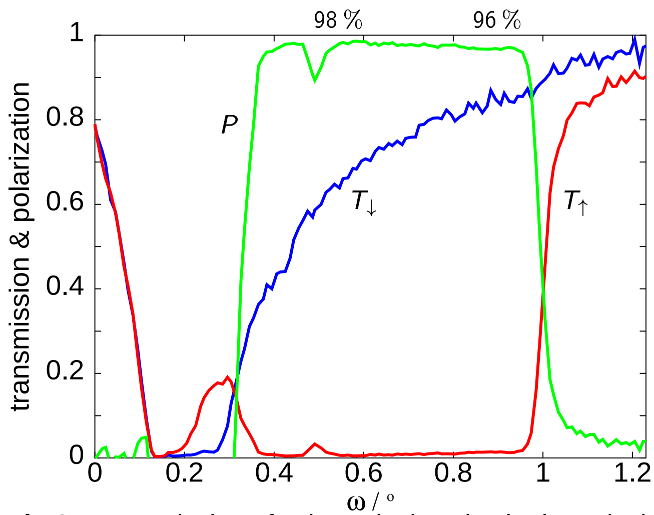

Fig.2: Transmission of spin up ($T_\uparrow$) and spin down ($T_\downarrow$) neutrons through a Fe / Si:N,O, $m = 2$ supermirror with 149 layers in total. After saturating the polarizer in a magnetic field of 300 G it was measured in a guide field of $<$ 20 G. The neutron wavelength was $\lambda = 4.74$ Å. The line denoted P gives the polarizing efficiency.

The main problem is the tensile stress in the Fe or $Fe_{.89}Co_{.11}$ layers. This can be partly compensated for by introducing compressive stress in the Si layers. But on the other side anisotropic stress is a condition for the wanted easy axis of magnetization. [2]

Neutron transmission (T) and reflectivity (R) curves of the supermirrors were measured on the 2 axes spectrometer TOPSI at SINQ. From these the polarizing efficiency was calculated without any further corrections:

$$P_T = \frac{T_\downarrow - T_\uparrow}{T_\downarrow + T_\uparrow} \qquad P_R = \frac{R_\uparrow - R_\downarrow}{R_\downarrow + R_\uparrow}$$

An example is given in Fig. 2.

If no remanence is required, it is easier to reduce stress and prepare polarizers with more layers, polarizing up to higher angles of incidence. Fig. 3 shows transmission and polarizing efficiency for an non-remanent $Fe_{.89}Co_{.11}$ / Si supermirror. Polarizers of this type (with $m = 2.5$ [3]) will be used on the SANS at SINQ.

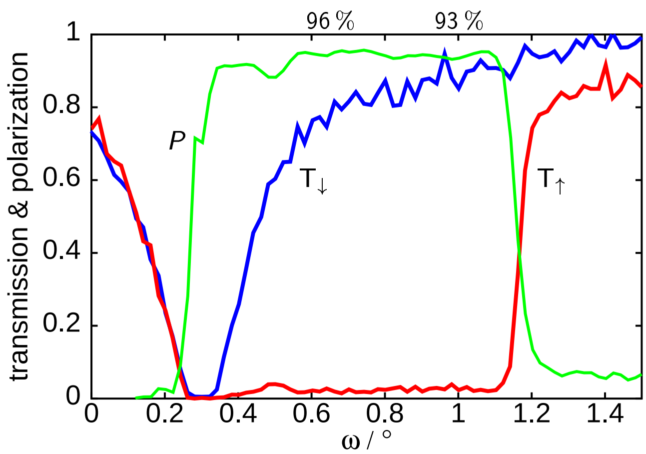

Fig.3: Transmission of spin up ($T_\uparrow$) and spin down ($T_\downarrow$) neutrons through a $Fe_{.89}Co_{.11}$ / Si, $m = 2.3$ supermirror with 299 layers in total. The polarizer was measured in a magnetic field of 300 G. ω gives the angle of incidence, the neutron wavelength was $\lambda = 4.74$ Å. The line denoted P gives the polarizing efficiency.

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[1] C.F. Majkrzak et al. SPIE **1738**, 90 (1992)
[2] M. Senthil Kumar, P. Böni, M. Horisberger, IEEE Transactions on Magnetics **35**, 3067 (1999)
[3] $m = 1$ corresponds to $4\pi \sin\omega/\lambda = 0.022$ Å^{-1}